“Real-Time/On-Line Modeling and Control of Cold-Flow Circulating Fluidized-Bed”

DOE/EPSCoR Lab Partnership Program
PI: Asad Davari PhD, WVU Tech
Collaborator: Lawrence Shadle PhD, NETL

ABSTRACT:
The goal of the research project is to seek methodologies and algorithms for real-time on-line modeling and intelligent control of large-scale nonlinear systems and to apply them to the circulating fluidized bed (CFB). The objective is to obtain an optimal convergence rate and an optimal learning rate of neural networks (NN) for real-time modeling and on-line control of the CFB in collaboration research with the National Energy Technology Lab (NETL). An off-line models and adaptive NN controllers have been developed for the stand pipe section of the CFB. One of the major obstacles in this approach has been the requirement for very low training times, as large training times would cripple the model and would not be effective to be implemented in real-time.

NETL currently uses CFB modeling and control to address the basic issues of design and operation to increase efficiency and lower emissions. The advanced control strategy would continually monitor the various operating parameters for the system and would be a major advance in intelligent control.

One attempt in this project is to build an online model for CFB using Wavelet Networks. Wavelet theory and neural networks are combined into a single method called wavelet networks to overcome the difficulties in the design of adaptive control system for nonlinear plants. No prior off-line training phase and no explicit knowledge of the structure of the plant are required. Construction of a wavelet network as an alternative to a neural network to approximate the highly nonlinear system CFB is specified and the simulation results are presented.

Another approach for modeling and control of CFB is using diagonal recurrent neural network (DRNN). The drawbacks of the usual Feed Forward Network (FNN) are that it is a static mapping and requires a large number of neurons and takes a long training time. The usual fixed learning rate fixed learning, which is based on empirical trail and error scheme, is slow and does not guarantee convergence. The architecture of DRNN is a modified model of the fully connected recurrent neural network with one hidden layer and the hidden layer is comprised of self recurrent neurons. A controlled plant is identified by the DRNN identifier, which provides the information of the plant to the DRNN controller, where the control action takes place. To ensure faster convergence, both the identifier and controller are trained using a Dynamic Back-Propagation (DBP) algorithm.